Wind Uplift

Bulletin 8

Forces Caused by the Wind

Designing structures and components, such as roofing, to withstand the damaging effects of the wind is an important aspect of engineering. During the 1970's and 1980's, many research studies were conducted using wind tunnels to measure the forces of the wind on various types of structures. Because these tests are both expensive and time-consuming, the American Society of Civil Engineers (ASCE) used the results from the research programs to develop a model that predicts wind forces on most structures. The method is described in ASCE 7-98 and is the generally accepted foundation for all of the major building codes. Using the model, a "Design Wind Pressure" in pounds per square foot (psf) is determined. This uplift pressure on roofing depends on many factors, including wind velocity, the location of the structure, roof slope, roof shape, roof height, and others. The "suction" forces of wind passing over the roof are considered, as well as increased pressure inside the building caused by wind entering through openings.

Wind Uplift Resistance Tests

Just as a model was developed to simplify the determination of pressures exerted by the wind, simple, standardized tests were needed to measure the wind resistance of various roofing systems. Three of the principal tests are described below. All of them are performed on a mockup, with a minimum size of 10 ft by 10 ft, which is placed in a chamber that is capable of exerting suction from above, pressure from beneath, or both.

UL 580 Standard for Tests for Uplift Resistance of Roof Assemblies.
This test is appropriate when the roofing product is a structural panel installed over open framing without the need for a solid deck. In some cases, it is also conducted on a roof covering attached to a particular solid substrate when the two are specified as a system. This test incorporates both pressure beneath the system and a vacuum above in an oscillating manner according to a specific test protocol. To achieve a UL Class 90 rating, the system must withstand a maximum positive pressure (pressure from below) of 48.5 psf combined with a maximum negative pressure (vacuum from above) of 56.5 psf, yielding a combined pressure differential of 105 psf. For Class 60 and Class 30 ratings, the maximum total pressures are 75 psf and 45 psf, respectively. Two points are particularly significant. First, the test is not run to failure, only to the specified limit. Second, when testing a roof covering fastened to a solid deck, the deck resists the pressure from below, and the roof covering only resists the vacuum from above, a maximum of 56.5 psf.

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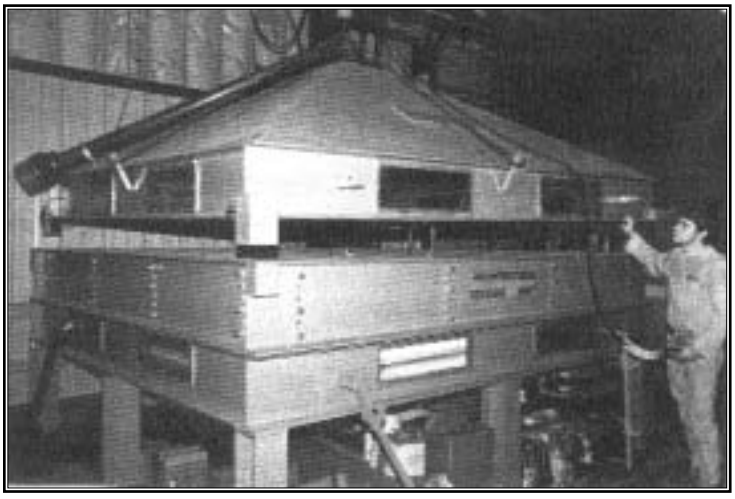
UL 1897 Standard for Uplift Tests for Roof Covering Systems.
This test evaluates the attachment of the roof covering systems to the roof decks. It is conducted by either pulling a vacuum above the assembly or by pressurizing an air bag placed loosely between the deck and the roof covering. (The second method is more common.) This test does not consider the strength of the roof deck, and the test is run to failure. The results are reported as the highest uplift pressure achieved prior to failure, commonly in pounds per square foot. The method does not necessarily simulate the actual dynamic uplift pressures encountered by roofing systems.

ASTM E 1592 Standard Test Method for Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference.
The purpose of this test is to measure the bending capacity and attachment strength when a system is subjected to a uniform static pressure. Use of this test method is restricted to standing seam, trapezoidal, ribbed or corrugated metal panels in the thickness range of 0.012 to 0.050 inch. When considering wind uplift resistance, air pressure is applied beneath the panels and attachments, frequently using a loosely installed plastic bag beneath the panels to maintain the pressure. Unlike the other two tests, deflections in the test panels are measured at no less than six locations. Baseline measurements are taken at a nominal pressure and then at each of the specified test pressures or until failure. The test pressure is relieved before progressing to the next higher pressure to determine whether there has been any permanent deformation. Test results are used in conjunction with wind design standards to determine required spacing of supports or attachments.



Typical chamber for testing uplift pressure.

Wrapping Up

An "Allowable Uplift Pressure" is calculated by applying an appropriate safety factor to the "Test Uplift Pressure" and then comparing it to the predicted "Design Wind Pressure". Roofing products are available in so many different materials, sizes, deck materials, support spacing, etc., that it is impossible to test every combination. Engineering analyses are sometimes required to determine the suitability of products for specific projects. In many cases it may be possible to increase the allowable uplift pressure by increasing the number of fasteners (reducing clip spacing).

Test methods continue to evolve as our understanding of wind and its effects improves. As an example, the commentary in ASCE 7-98 admits that air permeable roof coverings are unfairly penalized. Research proposals to develop a more appropriate test method for these products are being considered. Another chapter is still to be written.